

Claims

- [c1] A method of forming a material structure on a substrate, said material structure having a pattern containing features having a half-pitch of about 50nm or less, said method comprising:
- (A) providing a substrate with a layer of said material,
 - (B) applying a positive tone resist composition to said substrate to form a resist layer on said substrate, said resist composition comprising (a) an acid-sensitive imaging polymer matrix, and (b) a radiation-sensitive acid generator, said imaging polymer comprising a pendant acid-labile moiety having a low activation energy for acid-catalyzed cleaving,
 - (C) patternwise exposing said substrate to radiation whereby acid is generated by said radiation-sensitive acid generator in exposed regions of said resist layer,
 - (D) treating the exposed resist layer with a deprotection reaction-dependent co-reactant for a time sufficient to promote acid-catalyzed reaction in exposed portions of said resist layer but not so long as to cause resolution degradation due to acid diffusion-induced blur,
 - (E) developing a patterned resist structure in said resist layer by (i) removing radiation exposed portions of said resist if said resist is a positive tone resist, or (ii) removing non-radiation-exposed portions of said resist if said resist is a negative tone resist, and

(F)transferring resist structure pattern to said material layer by etching or ion implanting into said material layer through spaces in said resist structure pattern.

[c2] The method of claim 1 wherein said material is selected from the group consisting of organic dielectrics, metals, ceramics, and semiconductors.

[c3] The method of claim 1 wherein said acid-labile protecting group is a moiety selected from the group consisting of ketals, acetals and orthoesters.

[c4] The method of claim 1 wherein said transfer of step (F) comprises reactive ion etching.

[c5] The method of claim 1 wherein at least one intermediate layer is provided between said material layer and said resist layer, and step (F) comprises etching through said intermediate layer.

[c6] The method of claim 1 wherein the thermal processing temperature of step (D) is about 10-75°C.

[c7] The method of claim 1 wherein said deprotection reaction dependent co-reactant is present in the polymer film during exposure.

[c8] The method of claim 1 wherein the thermal processing temperature of step (D) is about 20-50°C.

- [c9] The method of claim 1 where water is employed as co-reactant.
- [c10] The method of claim 1 wherein said exposure of step (C) is done under anhydrous conditions.
- [c11] The method of claim 9 wherein the thermal processing of step (D) is performed in a water vapor-containing atmosphere having a relative humidity of about 10 to 80%.
- [c12] The method of claim 1 wherein step (D) is conducted for about 0.5 to 45 minutes.
- [c13] The method of claim 12 wherein step (D) is conducted for about 1 to 5 minutes.
- [c14] The method of claim 1 wherein said radiation used in step (C) has a wavelength selected from the group consisting of 248 nm, 193 nm, 157 nm, 13.4 nm, 1.4 nm, and 1.1 nm.
- [c15] The method of claim 1 wherein said radiation used in step (C) is extreme ultraviolet.
- [c16] The method of claim 1 where said radiation used in step (C) is selected from the group consisting of with electron beam and ion beam.
- [c17] The method of claim 1 where the acid labile group comprises acetal, ketal, or orthoester groups requiring water as a co-reactant to form a developable image.

[c18] A method of forming a material structure on a substrate, the material structure having a pattern containing features having a half-pitch of about 50nm or less, the method comprising:

- (A) providing a substrate,
- (B) applying a positive resist composition to the substrate to form a resist layer on the substrate, the resist composition comprising (a) an acid-sensitive imaging polymer matrix, and (b) a radiation-sensitive acid generator, the imaging polymer matrix comprising a pendant acid-labile moiety having a low activation energy for acid-catalyzed cleaving,
- (C) patternwise exposing the substrate to radiation whereby acid is generated by the radiation-sensitive acid generator in exposed regions of the resist layer,
- (D) post-exposure processing of the exposed resist layer in the presence of a deprotection reaction-dependent co-reactant for a time sufficient to promote the acid-catalyzed reaction in exposed portions of the resist layer but not so long as to cause resolution degradation due to acid diffusion-induced blur,
- (E) developing a patterned resist structure in the resist layer by removing radiation exposed portions of the resist, and
- (F) transferring resist structure pattern to the material by depositing the material onto the substrate at spaces in the resist structure pattern.

[c19] The method of claim 18 wherein said deposition of step (F) is

done by electroplating, chemical vapor deposition or physical vapor deposition.